REACTION OF NITROGEN TETROXIDE WITH 2-VINYLTHIOPHENE AND SUBSTITUTED 2-VINYLTHIOPHENES

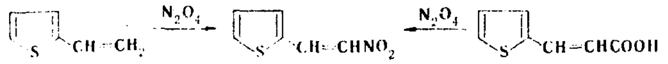
A. I. Sitkin and V. I. Klimenko

UDC 542.958.1:547.732

1-(2-Thienyl)-2-nitroethylene was obtained by the reaction of nitrogen tetroxide with 2-vinylthiophene and 3-(2-thienyl)acrylic acid. The nitration of thenylideneacetone leads to 1-(2-thienyl)-2-nitro-3-methylpropen-3-one, whereas the products of the reaction of nitrogen tetroxide with thenylideneacetothienone and -acetophenone are mixtures of isomers with a nitro group attached to the ethylene bond or in the thiophene ring. 5-Nitro-2-thienyl analogs of chalcone were isolated as products of the nitration of benzene-ring-substituted thenylideneacetophenones.

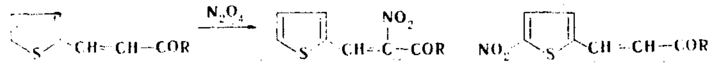
(5-Nitro-2-thienyl)alkenes are obtained as a result of the reaction of 2-thienylalkenes with nitric acid in acetic anhydride [1, 2]; however, there is no information relative to the direction of their reaction with nitrogen tetroxide. The present research was devoted to a study of the nitration of 2-vinylthiophene and substituted 2-vinylthiophenes with nitrogen tetroxide.

The reaction of 2-vinylthiophene (I) with nitrogen tetroxide leads to 1-(2-thienyl)-2-nitroethylene (II). As in the nitration of arylalkenes (for example, see [3]), the reaction probably proceeds through intermediate nitro nitrite and nitro alcohol intermediates, which readily split out, respectively, the elements of nitrous acid and water. Nitroalkene II is also obtained from 3-(2-thienyl)acrylic acid (III).



I II III

However, the reaction of nitrogen tetroxide with thenylidene ketones IV proceeds via different pathways; this is evidently associated with the volume of the substituent in the acyl group.



IV a-i V a-c VI b-i

IV—VI a $R=CH_3$; b R=2-thienyl; c $R=C_6H_5$; d $R=4\text{-}CH_3OC_6H_4$; e $R=4\text{-}CH_3C_6H_4$; f $R=4\text{-}ClC_6H_4$; g $R=4\text{-}BrC_6H_4$; h $R=4\text{-}IC_6H_4$; i $R=4\text{-}NO_2C_6H_4$

Like I and III, thenylideneacetone IVa reacts with nitrogen tetroxide to give nitro derivative Va. In the case of the nitration of thenylidene ketones IVb,c, which contain bulkier thienyl and phenyl substituents in the acyl residue, the reaction proceeds via two pathways to give a mixture of isomers of the V and VI type, which are separated by fractional crystallization. In the case of benzene ring-substituted thenylideneacetophenones IVd-i, regardless of the character of the substituents, the nitration products are 5-nitro-2-thienyl analogs of chalcone (VId-i). Nitro compounds of this type can also be synthesized by nitration of thenylideneacetophenones with nitric acid in acetic anhydride containing catalytic amounts of sulfuric acid. For example, nitro derivative VId was obtained in 93% yield from ketone IVd by this method.

Kuzbas Polytechnic Institute, Kemerova 650026. Translated from Khimiya Geterotsiklicheskikh Soedinenii, No. 1, pp. 41-43, January, 1979. Original article submitted November 14, 1977; revision submitted May 23, 1978.

0009-3122/79/1501-0034$07.50

TABLE 1. Nitro Derivatives II, V, and VI

Compound	Preparative method[a]	mp, °C	Yield, %	2,4-Dinitrophenylhydrazones, mp, °C
II	A (1 : 5)	79–80[b][4]	35	—
Va	A (1 : 1)	147–148[c]	54	208–209
Vb	A (1 : 1)	146–147[d]	23	247–248
Vc	A (1 : 1)	130–131[e]	22	228–229
VIb	A (1 : 1)	188–189[d] [5]	8	—
VIc	A (1 : 1)	180–181[f] [6]	13	244–245
VId	A (1 : 3)	211–212[f] [6]	25	217
VIe	A (1 : 3)	189–190[g] [7]	24	—
VIf	A (1 : 3)	226–227[h]	45	208–209[i]
	B	226–227	76	208–209
VIg	A (1 : 3)	227–228[f] [7]	42	—
VIh	A (1 : 3)	219–220[j,k]	38	235–236[l]
	B	219–220[j]	31	235–236
VIi	A (1 : 3)	259–260[j] [6]	43	—

---

a) The molar ratio of the starting compound to N_2O_4 is indicated in parentheses. b) from carbon tetrachloride. c) From chloroform. d) From ethanol. e) From methanol. f) From acetic acid. g) From benzene. h) From nitrobenzene. Found: C 53.4; H 2.7; Cl 12.3; N 4.8; S 10.6%. $C_{13}H_8ClNO_3S$. Calculated: C 53.2; H 2.7; Cl 12.1; N 4.8; S 10.9%. i) Found: Cl 7.3; N 15.0; S 7.1%. $C_{19}H_{12}ClN_5O_6S$. Calculated: Cl 7.5; N 14.8; S 6.8%. j) From nitromethane. k) Found: C 40.4; H 2.3; I 32.7; N 3.9; S 8.5%. $C_{13}H_8INO_3S$. Calculated: C 40.5; H 2.1; I 32.9; N 3.6; S 8.3%. l) Found: I 22.7; N 12.6; S 5.5%. $C_{19}H_{12}IN_5O_6S$. Calculated: I 22.4; N 12.4; S 5.7%.

It must be noted that II, Va-c, and VIb-i can be obtained by means of nitrogen tetroxide only at low temperatures (from –15 to –20°C). Slight warming of the reaction mixture leads to resinification. Under the previously found conditions halo- and nitro-substituted thenylideneacetophenones IVf-i do not react completely but are easily separated from the nitration products by recrystallization.

The structures of nitro compounds II and VIb-e,g,i were proved by the agreement with the constants described in the literature [4-7], the absence of melting-point depressions for mixtures with authentic samples, and the completely identical character of their IR spectra. The structure of ketones VIf,h was confirmed by their alternative synthesis from 2-formyl-5-nitrothiophene and 4-haloacetophenones. The structure of nitro ketones Va-c was established by IR spectroscopy. The constants and yields of the compounds obtained are presented in Table 1. The results of elementary analysis of nitro ketones Va-c and their 2,4-dinitrophenylhydrazones and the assignment of the absorption bands in the IR spectra of Va-c were presented in [8].

A trans configuration and a cisoid orientation of the carbonyl group and the ethylene bond were established for a number of thiophene analogs of chalcone and their 5-nitrothienyl derivatives from the IR spectral data and measurements of the dipole moments of the molecules [9, 10]. We checked the configuration of thienyl- and 5-nitrothienylpropenones IVb-i and VIb-i by the presence in the IR spectra of frequencies of out-of-plane deformation vibrations of C-H bonds of trans-disubstituted conjugated ethylenes (975-987 cm^{-1}) [7]. The higher intensity of $\nu_{C=C}$ as compared with $\nu_{C=O}$ ($\nu_{C=O}/\nu_{C=C}$ = 0.8-0.9) and the difference between these frequencies ($\Delta\nu$ = 55-65 cm^{-1}) indicate that the carbonyl group and the vinylene group conjugated with it exist in an s-cis configuration in these ketones [7, 10].

EXPERIMENTAL

The IR spectra of KBr pellets of the compounds (0.25%) were recorded with a UR-20 spectrometer. Thin-layer chromatography (TLC) was carried out on Silufol UV-254 plates with elution by benzene and development in UV light.

Starting I and III were obtained by the methods in [11, 12], while IVa-f,h,i were obtained by crotonic condensation of 2-formylthiophene with the corresponding ketones [13-17]. Thenylidenebromoacetophenone IVg was synthesized by the method in [18].

Nitro Compounds II, V, and VI. Nitrogen tetroxide was added at −17°C to a solution of 20 mmole of the thiophene derivative in 40 ml of absolute ether (see Table 1 for the molar ratios of the components), and the mixture was stirred at −17°C for 2 h, after which it was poured over 100 g of finely crushed ice. The water was then removed, the ether was evaporated, and the solid material was washed successively with water, alcohol, and ether and dried. This procedure was used to obtain nitro ketones Va–c and VIb–i. Dichloroethane was used as the solvent in the nitration of alkene I, and the organic layer isolated after similar workup of the reaction mixture was subjected to steam distillation; the resulting light-yellow acicular crystals of II were removed by filtration and dried. Nitroalkene II was obtained in 30% yield from acid III by an identical method.

B) A 1-ml sample of concentrated sulfuric acid was added to a solution of 20 mmole of 2-formyl-5-nitrothiophene and 20 mmole of 4-haloacetophenone in 15 ml of acetic acid. After 12 h, the crystals of the nitro ketone were removed by filtration and washed with water and alcohol to give nitro ketones VIf,h. IR spectrum of VIf: 1670 (C=O); 1606 (C=C); 1354, 1535 (NO_2); 738 (C–Cl); 710, 1033, 1430, 1505, 3100, and 3120 cm^{-1} (vitrations of the thiophene ring). IR spectrum of VIh: 1665 (C=O); 1600 (C=C); 1338, 1500 (NO_2); 485 (C–I); 734, 1040, 1430, 1530, 1585, 3084, and 3100 cm^{-1} (vibrations of the thiophene ring).

1-(5-Nitro-2-thienyl)-3-(4-methoxyphenyl)propen-3-one (VId). A solution of 0.99 g (4 mmole) of ketone IVd in 20 ml of acetic anhydride was added dropwise at −10°C to a mixture of 10 ml of acetic anhydride, 1.51 g (24 mmole) of nitric acid (sp. gr. 1.51), and 0.1 ml of concentrated sulfuric acid, and the mixture was stirred for 1 h. The precipitate was removed by filtration and washed to neutrality with water. The yield of VId, with mp 212°C (from acetic acid) [6], was 1.1 g (93%).

2,4-Dinitrophenylhydrazones of Nitro Ketones Va–c and VIc,d,f,h. A hot solution of 1 mmole of 2,4-dinitrophenylhydrazine in 5–10 ml of alcohol acidified with concentrated hydrochloric acid (0.5–2 ml) was added to a hot saturated solution of 1 mmole of the ketone in ethanol, and heating was continued for 40 min (for 5 h for VIf,h). The precipitate was removed by filtration, washed with alcohol and ether, and recrystallized from acetic acid.

LITERATURE CITED

1. G. Combes, M. Heblelunck, and J. Ledrut, Bull. Soc. Chim. France, No. 2, 315 (1953).
2. V. S. Egorova, V. N. Ivanova, and N. I. Putokhin, Khim. Geterotsikl. Soedin., No. 5, 829 (1967).
3. A. D. Nikolaeva, A. I. Sitkin, and G. Kh. Kamai, Zh. Org. Khim., 4, 2116 (1968).
4. V. King and F. Nord, J. Org. Chem., 14, 405 (1949).
5. A. Corvaisier, Bull. Soc. Chim. France, No. 3, 528 (1962).
6. S. V. Tsukerman, V. M. Nikitchenko, and V. F. Lavrushin, Zh. Obshch. Khim., 32, 2324 (1962).
7. V. N. Listvan, Khim. Geterotsikl. Soedin., No. 12, 1624 (1974).
8. A. I. Sitkin, V. I. Klimenko, and A. L. Fridman, Zh. Org. Khim., 13, 2623 (1977).
9. S. V. Tsukerman, V. M. Nikitchenko, V. D. Orlov, and V. F. Lavrushin, Khim. Geterotsikl. Soedin., No. 2, 232 (1967).
10. V. I. Savin and Yu. P. Kitaev, Zh. Org. Khim., 9, 1101 (1973).
11. Organic Syntheses [Russian translation], Vol. 10, Inostr. Lit., Moscow (1960), p. 16.
12. H. Biedermann, Ber., 19, 1855 (1886).
13. E. Grishkevich-Trokhimovskii and I. Matsurevich, Zh. Russk. Khim. Obshchestva, 44, 574 (1912).
14. C. Weygand and F. Strobelt, Ber., 68, 1839 (1935).
15. V. F. Lavrushin, S. V. Tsukerman, and V. M. Nikitchenko, Ukr. Khim. Zh., 27, 378 (1961).
16. S. V. Tsukerman, V. M. Nikitchenko, B. I. Ostrovskaya, and V. F. Lavrushin, Ukr. Khim. Zh., 32, 1194 (1966).
17. N. P. Buu-Hoi, Bull. Soc. Chim. France, Nos. 11-12, 1646 (1956).
18. V. F. Belyaev and A. I. Abrazhevich, Khim. Geterotsikl. Soedin., No. 2, 228 (1967).